PROTOCOL DEVELOPMENT SUMMARY

Protocol: OLYM Vital Signs Monitoring of Sub-Alpine Lake Water Quality

Parks where protocol may be implemented: The sub-protocol of the NCCN Mountain Lakes Protocol outlined below will be implemented at OLYM and complements the sub-protocols being developed at NOCA and MORA. The standard operating procedures will be similar at all three parks, and are based on the USGS-BRD Mountain Lake Standard Operating Procedures. However the sampling design differs between the NCCN parks to serve the specific monitoring needs of those parks.

Justification:

Lake water quality was ranked 7th as a potential vital sign in the NCCN. OLYM, NOCA, and MORA all have substantial numbers of high elevations lakes and ponds. These water bodies are vital components of park high elevation ecosystems. They serve as valuable indicators of landscape and regional stressors, in addition to serving as reference systems for high elevation water bodies in areas that do not enjoy the protection afforded by the National Park Service. Stressors that affect high elevation water bodies include: global climate change, air pollution, degradation through visitor use, and anthropogenic introduction of exotic species.

Monitoring Questions & Objectives:

Program Goals: The general goals of long term sub-alpine lake monitoring in OLYM are to:

- Determine the status and trends in selected indicators of sub-alpine lake water quality and ecosystem condition.
- Provide early warning of abnormal conditions to help develop effective mitigation measures.
- Provide data to better understand the dynamic nature and condition of sub-alpine lake ecosystems, and provide reference points for comparison with other, altered systems.

OLYM Sub-alpine lake Step-Down Framework

- High Lake Ecosystem Integrity
  - Trends in Water Quality in set of inferential reference water bodies
    - Trends in physical/chemical/biological properties of water column
    - Trends in inferred primary productivity.
  - Status of fish and amphibian populations in reference water bodies
    - Presence/absence status of amphibian assemblages
    - Presence/absence status of exotic fish assemblages
  - Status of watershed condition
    - Determination of watershed condition

Monitoring Questions Associated with Step-down Framework

- What are the trends and status of sub-alpine lake water quality and biotic integrity?
    - What is the status and long term trends in water quality of sub-alpine waters?
        - What is the status and the long term trend in physical, chemical and biological properties of sub-alpine lake water columns?
        - What is the presence/absence status and trend in exotic fish populations in the reference sub-alpine lakes?
        - What is the presence/absence status and trend in amphibians in the reference sub-alpine lakes?
        - What is the magnitude of visitation impact on the watershed condition of the reference sub-alpine lakes?

Monitoring Objectives:

1. Determine the natural variation and long term trends in selected physical, chemical and biological water quality parameters in 5 focal reference lakes/ponds. ***Justification*** *The USGS-BRD Montane Lakes and Ponds Scientific Panel recommended intensive monitoring on a set of 5 focal lakes and ponds. The panel felt that sampling the same water bodies twice every year would provide adequate data to determine water quality trends and potential controlling factors. In the trade-off between sampling more lakes versus intensively sampling a set of lakes, broader inferential designs meant to census a greater portion of the sub-alpine lake population were considered less useful because of 1) intra-lake seasonal variability, 2) inter-lake variability in water quality parameters, 3) general inaccessibility of lakes at OLYM leading to, 4) the infeasibility of sampling a sufficient number of lakes to provide valid trend information even over a 10 year period, and 5) the presumption that widespread stressors operating at the landscape scale over the long-run would be adequately detected in a suite of reference sites sampled intensively.*
2. Determine the status and trend of amphibian assemblages in 5 focal lakes. ***Justification:*** *Amphibians are important constituents of sub-alpine lake food webs, where they are often the dominant vertebrate predator in fishless systems. Amphibians are also particularly sensitive to environmental changes, making them important indicators of ecosystem stressors.*
3. Determine the status of exotic fish assemblages in the reference lakes. ***Justification****: The introduction of exotic fish into high elevation lake/pond systems has been a major perturbation to these aquatic foodwebs. Fish become the dominant predator and change the composition, size-structure, and nutrient dynamics of the lake/pond foodweb. Through the sampling design proposed here, we will be able to determine the status of exotic fish presence in the reference lakes and determine temporal trends in their abundance and condition. Additionally, because 4 of the lakes are randomly chosen from the entire sub-alpine lake population, weak inference can be made to the entire sub-alpine lake population.*
4. Determine the degree of impact of visitor use on shoreline condition in the reference lakes. ***Justification*****:** *As visitation to backcountry sub-alpine lakes increases, visitors are expected to impact the watersheds of these systems by altering shoreline vegetation, increasing erosion, and introducing sediments into the water. Monitoring over long periods of time will enable us to determine how these systems respond to restoration activities and management decisions.*

Basic Approach:

The lake population considered in this OLYM sub-protocol is the sub-alpine lake population. This population is the most numerous set of lakes in OLYM, and is also the most accessible of the high elevation lakes. Sub-alpine lakes at OLYM are defined as those lakes occurring between 4000-6000 ft in elevation and between 0.2 to 4.0 hectares in surface area. The four lakes randomly chosen from this population were divided into two precipitation gradient strata, "wet" and "dry". OLYM is a mountainous region exposed to a severe east/west precipitation gradient. The influence of this gradient on temporal changes in lake attributes is of great interest to the park. The selected reference lakes are detailed in Table 1.

The sampling design, parameters to be measured, and frequency of measurement are detailed in Table 2. This sub-protocol proposes to monitor five reference sub-alpine lakes, with two visits per year, one shortly after ice-out and the other towards the end of the summer. Four of the lakes are randomly chosen from the entire population of OLYM sub-alpine lakes. The fifth (Hoh lake), is a non-random judgment sample, selected because there is a wealth of historical climatological, watershed, and atmospheric deposition data associated with it. These data may aid in future interpretation of trends identified by the proposed sampling program. This design allows for the determination of trends in selected physical, chemical, and biological water quality parameters. The annual schedule of events is detailed in Table 3.

Table 1: Selected OLYM sub-alpine reference lakes

OLYMPIC NATIONAL PARK	Random "wet"	Random "dry"	Non-Random "legacy"	Elevation (ft)	Surface Area (ha)
Francis Shelter (lake #368)	X			4080	0.4
Milk Lake (lake #498)		X		4708	1.1
Lake Success (lake #578)	X			4149	0.4
Thousand Acre Meadow (lake #256)		X		5751	0.5
Hoh Lake (lake #88)			X	4539	7.4

Prinicpal Investigator/NPS Leads: The protocol standard operating procedures were developed by USGS-BRD staff: Bob Hoffman, Gary Larson. The OLYM lead is Steven Fradkin. The NOCA lead is Reed Glesne. The MORA is Barbara Samora.

Development Schedule, Budget, Expected Interim Products:

USGS protocols for sampling montane lakes and ponds and recommendation from the USGS Sub-alpine lake Scientific Panel will be integrated at the park level within the NCCN to meet the specific monitoring and management needs of each park. A draft sub-alpine lake protocol that meets NPS standards (Oakley et al. 2003) is expected to be ready for external peer review by April, 2006. See Table 4 for estimated budget.

Table 2: Vital Signs Monitoring of Ecological Condition of OLYM Sub-Alpine Lakes

Target Population - Naturally occurring sub-alpine lakes between 4000-6000 ft with surface area between 0.2 and 4.0 ha

Site Selection - 4 randomly chosen lakes from sub-alpine lake population. 2 lakes from each of two precipitation strata (wet & dry). 1 non-random judgment lake chosen because of rich historical watershed and atmospheric data.

Sampling Design - 5 fixed sites sampled twice per year (beginning and end of ice-free season

Indicators	**Sample frequency**	**Method**	**Response Variables**
Biological			
Fish - Frequency of occurrence	All sites, every visit	-visual,gillnets, angling	-Presence/absence
Amphibian – Frequency of occurrence			
Zooplankton		- vertical plankton net tows	-Species richness, time series mean
Submergent aquatic macrophytes		-Shoreline surveys	-Presence/absence of exotics, %cover
Physical			
Water temperature-continuous, top/mid/bottom	All sites, all year	-permanent data loggers	-daily mean, date of ice-out
Lake level	All sites, every visit	- local benchmark	-Site level trends in annual fluctuation.
Secchi transparency		- Secchi depth	-Trends in secchi depth at site level.
Basin characteristics - surface area, perimeter, inlets and outlets, vegzone, reference photos	Decadal	-Shoreline surveys	-Classification attributes not expected to change
Shore Disturbance- erosion, % habitat cover	All sites, every visit	-Shoreline surveys	-Erosion, bare ground, emergent veg.
Near-shore substrate composition			-Site level trends in composition of substrate types.
Chemical			
Dissolved Oxygen, Conductivity, temperature	All sites, every visit	- Vertical profile, YSI Meter	-Site trends in parameters, Depth at oxycline, D.O. near bottom
Alkalinity, pH, Total Dissolved Solids, Dissolved Organic Carbon	All sites, every visit	-(Hoffman et al. 2003)	-Site trends in parameters and productivity
<u>Nutrients/productivity</u> -Chlorophyll a -Ammonia, Nitrate -Total Kjehldahl Nitrogen -Total Phosphorus -SO_4	All sites, every visit	-(Hoffman et al. 2003)	-Site trends in parameters and productivity

Table 3: Annual schedule of events for OLYM sub-alpine lake monitoring:

Month	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Week	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15
Hiring																								
Training																								
Data Collection																								
Data Entry																								
QA/QC																								
Reporting																								
Records Mgmt																								

Table 4: OLYM Sub-Alpine Lake Budget
Based on 10 lake visits (2 visits per lake per season)

Salaries and Benefits	**Job component**	**PP**	**Cost**
GS5 seasonal	Data collection	5	5300
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GS5 seasonal	Data collection	4	4240
GS7 Permanent STF	Data Collection	1	2100
		22	**$16,940**

Field Per Diem (115 days x $20/day)	**$2,300**
Vehicles collateral w/ other projects	**$0**
Services	
Water Chemical Analysis (10 samples @ $240/sample)	**$2,400**
Supplies and Equipment (waders, dry suits, nets, meters, camping and backpacking supplies, lake physical sampling equipment, waterproof paper, nets, sampling equipment and supplies, water sampling supplies, office equipment and supplies, temperature loggers, etc.)	**$1,130**

OLYM GRAND TOTAL (without fish tissue samples) = **$22,770**

* Salaries based on 2005 OLYM tables.

GS 5 calculated as ave for step 1 $ with seasonal benefit rate of 7.6%